



Maintaining Our Technological Advantage in an Era of Uncertainty

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The Future?

**"I think there is a world market for maybe five computers."
(Thomas Watson, IBM Chairman, 1943)**

**"640K ought to be enough for anybody."
(Bill Gates, CEO of Microsoft, 1981)**

**"Airplanes are interesting toys but of no
military value." (Marechal Ferdinand
Foch, Professor of Strategy, 1904)**

**"It is tough to make predictions,
especially about the future." (Yogi Berra)**

**"The best way to predict the future is to
invent it." (Alan Kay)**

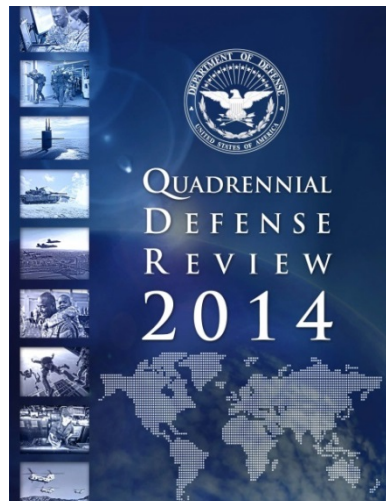
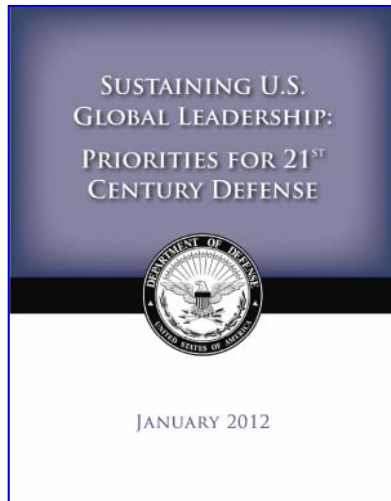




Key Elements of 2014 Quadrennial Defense Review



- Builds on the 2012 Defense Strategic Guidance by outlining an updated defense strategy that protects and advances U.S. interests and sustains U.S. leadership.
- Describes how the Department is responsibly and realistically taking steps to rebalance major elements of the Joint Force given the changing environment.
- Demonstrates our intent to rebalance the Department itself as part of our effort to control internal cost growth that is threatening to erode our combat power in this period of fiscal austerity.



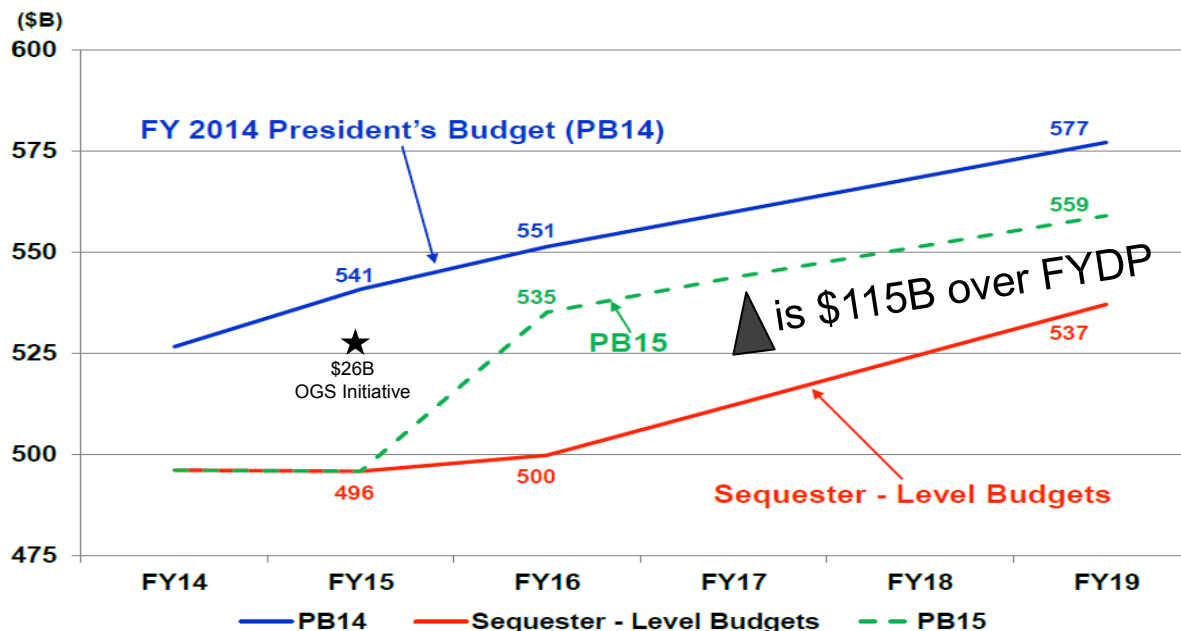


Strategic Future and Fiscal Uncertainty



“In the next 10 years, I expect the risk of interstate conflict in East Asia to rise, the vulnerability of our platforms and bases to increase, our technology edge to erode, instability to persist in the Middle East, and threats posed by violent extremist organizations to endure. Nearly any future conflict will occur on a much faster pace and on a more technically challenging battlefield.”

PB15 DoD Base-Budget Topline



OGS: Opportunity, Growth, and Security

GEN Dempsey, CJCS
QDR Assessment





DoD at Strategic Crossroads



Chuck Hagel

Budget Roll Brief
24 Feb 2014

“The development and proliferation of more advanced military technologies by other nations means that we are entering an era where American dominance on the seas, in the skies, and in space can no longer be taken for granted.”

The strategic question is – will the force of tomorrow be:

- Larger with diminished capability or,
- Smaller with more technologically advanced capabilities



USD(AT&L) Priorities

Concern of Losing Technological Edge



Frank Kendall

USD (AT&L)

Mr. Kendall on the
Department's Technological
Edge, January 2014

"I'm very concerned about eroding technological superiority."

- DoD's R&D spending declined 14% since 2009
 - We have to preserve the future capability

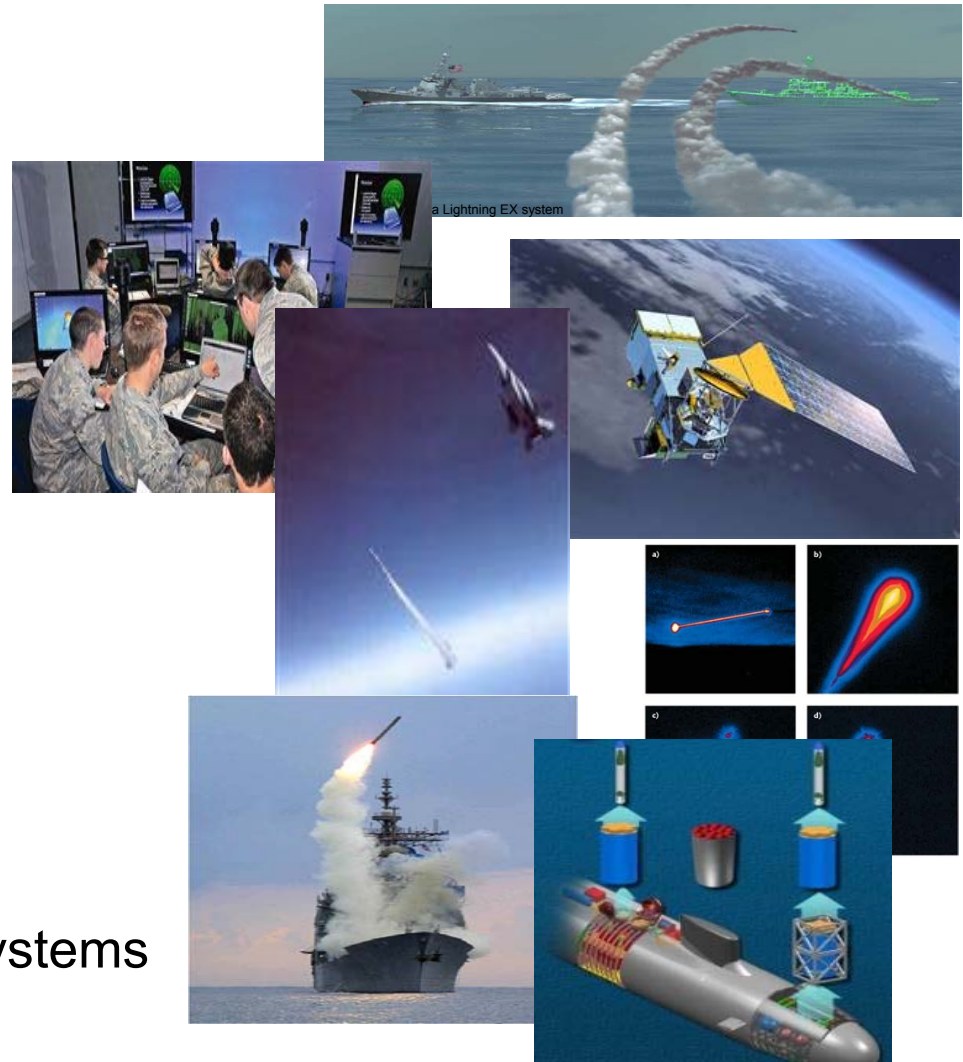
"We're in a cyclical downturn right now. It will end, and then there will be an upturn. The people who are prepared with products that we need or who have done the technology to build the products that we will need will be much better positioned when that upturn occurs."



Anti-Access/ Area Denial

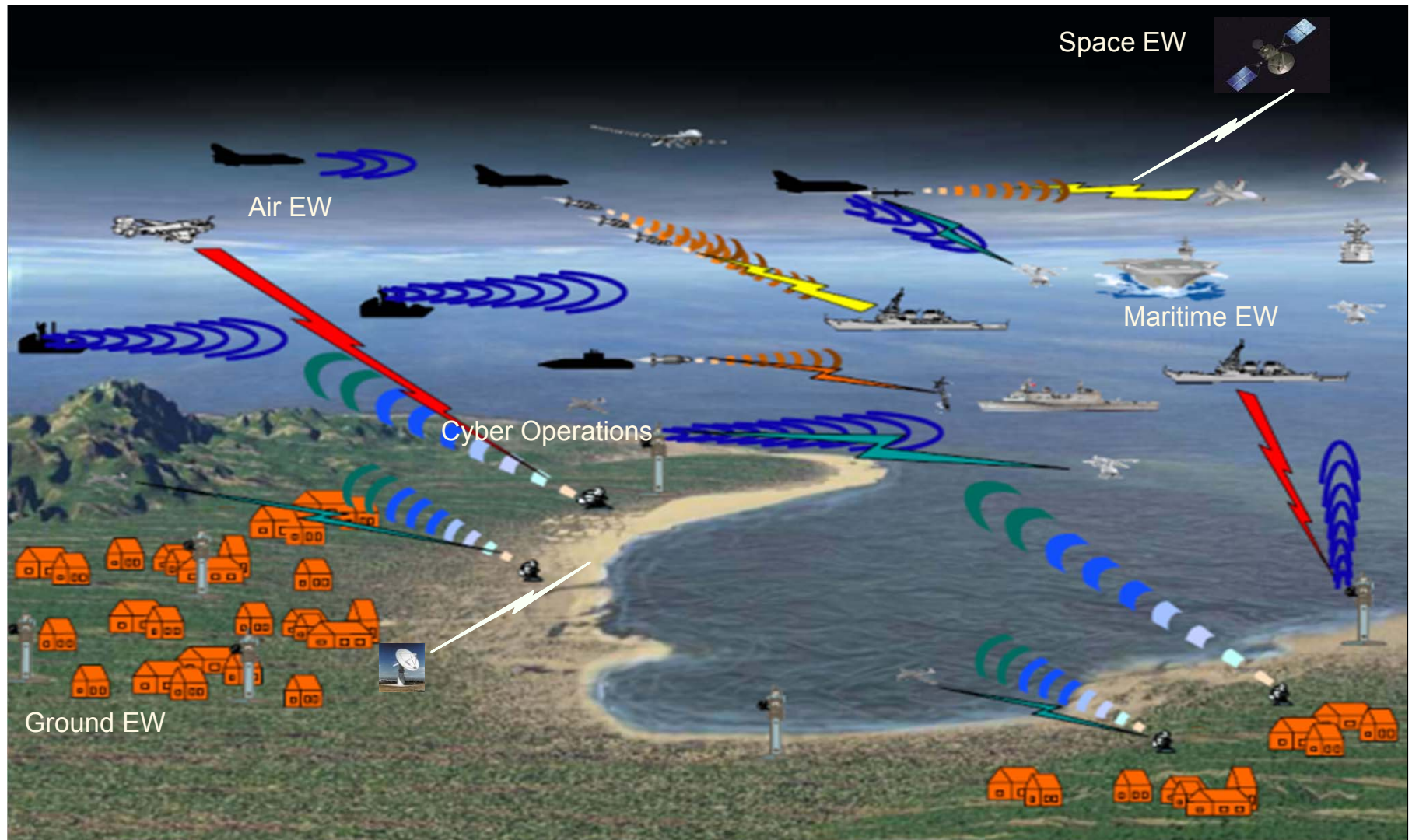


- Electronic Warfare (EMS) / Electronic Protection
- Cyber Operations
- Space / Counter Space
- Undersea Operations
- Counter Missile / Missile Defense
- Counter Integrated Air Defense Systems





Effects at All Levels and In All Domains



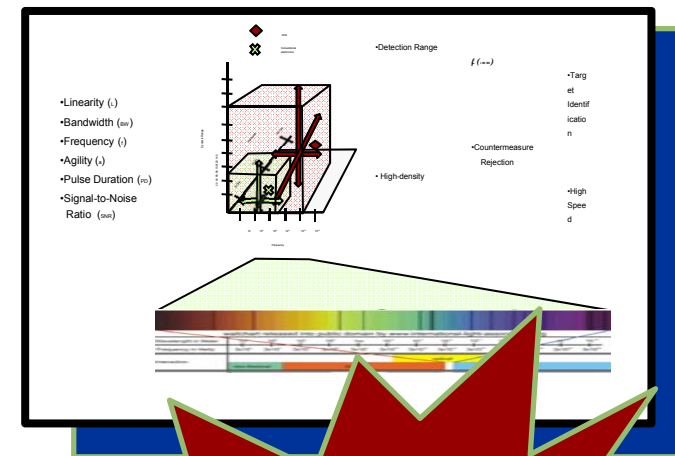


Electronic Warfare



U.S. EW Superiority is Being Broadly Challenged

- Digital signal processing expanding
- Threat systems more lethal, longer range, mobile
- Sensors are networked and active – passive combinations are appearing
- Radar and radio systems are trending to software-driven waveform generators
- Weapon seekers are more sophisticated with spectral diversity and ECCM processing
- Advanced jamming techniques and technologies are now available to adversaries



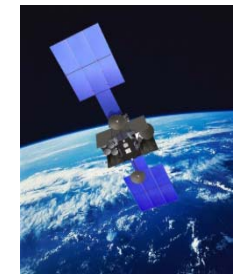
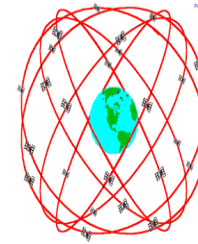
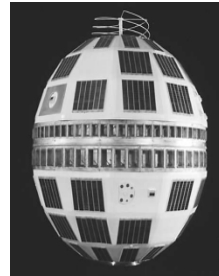
**OPPORTUNITIES
FOR NEW
APPROACHES**



Globally Accelerating Technology



Research Drives Military Advantage



40s	50s	60s	70s	80s	90s	00s
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<ul style="list-style-type: none"> • Nuclear weapons • Radar • Proximity fuse • Sonar • Jet engine • LORAN 	<ul style="list-style-type: none"> • Digital computer • ICBM • Transistor • Laser technology • Nuclear propulsion • Digital comm. 	<ul style="list-style-type: none"> • Satellite comm. • Integrated circuits • Phased-array radar • Defense networks • Airborne surv. • MIRV 	<ul style="list-style-type: none"> • Airborne GMTI/SAR • Stealth • Strategic CMs • IR search and track • Space track network • C2 networks 	<ul style="list-style-type: none"> • GPS • UAVs • Night vision • Personal computing • Counter-stealth • BMD hit-to-kill 	<ul style="list-style-type: none"> • Wideband networks • Web protocols • Precision munitions • Solid state radar • Advanced robotics • Speech recognition 	<ul style="list-style-type: none"> • GIG • Armed UAVs • Optical SATCOM • Data mining • Advanced seekers • Decision support
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DoD Research Program



- **Six high priority S&T areas for DoD**
 1. Metamaterials and Plasmonics
 2. Quantum Information Science
 3. Cognitive Neuroscience
 4. Nanoscience and Nanoengineering
 5. Synthetic Biology
 6. Understanding Human and Social Behavior
- **Within the broader set of sciences critical to DoD**



Trends in basic research are identified and judged through a variety of interactions, including:

- Publications, university site visits, conference attendance
- Future Directions Workshops (identifying emerging areas for investment and International Centers of Excellence for collaborative opportunities)
- Engage expert panels (JASONs, National Academy of Sciences, etc...)

Understanding and creating the cutting edge



Defense R&E Strategy

“Protect and prioritize key investments in technology and new capabilities, as well as our capacity to grow, adapt and mobilize as needed.”

-SECDEF, January 2012 Strategic Guidance

1. **Mitigate** new and emerging threat capabilities

- Cyber
- Counter Space
- Electronic Warfare
- Counter-WMD

2. **Affordably** enable new or extended capabilities in existing military systems

- Systems Engineering
- Prototyping
- Interoperability
- Modeling and Simulation
- Developmental Test & Evaluation
- Power & Energy

3. Develop **technology surprise** through science and engineering

- Autonomy
- Human Systems
- Quantum
- Data-to-Decisions
- Hypersonic

Technology Needs



- Cyber / Electronic Warfare
- Engineering / M & S
- Capability Prototyping
- Protection & Sustainment
- Advanced Machine Intelligence
- Anti-Access/Area Denial (A2/AD)



Pace of Technology

Black Swan Syndrome

Rise of the Commons

Expanding Global Knowledge Base

Information Agility

Mass Collaboration

Economic and S&T Mega-Trends

Technology Commercialization

Cloud Computing

skype facebook MTN Bank

SECOND LIFE

WIKIPEDIA a place for friends

myspace.com

del.icio.us

Wi-Fi Digg

YouTube flickr twitter



Pace of Technology

High-tech leapfrog

Number of years after invention for selected technologies to reach 80% country coverage

1750-1900



1900-50



1950-75



1975-2000



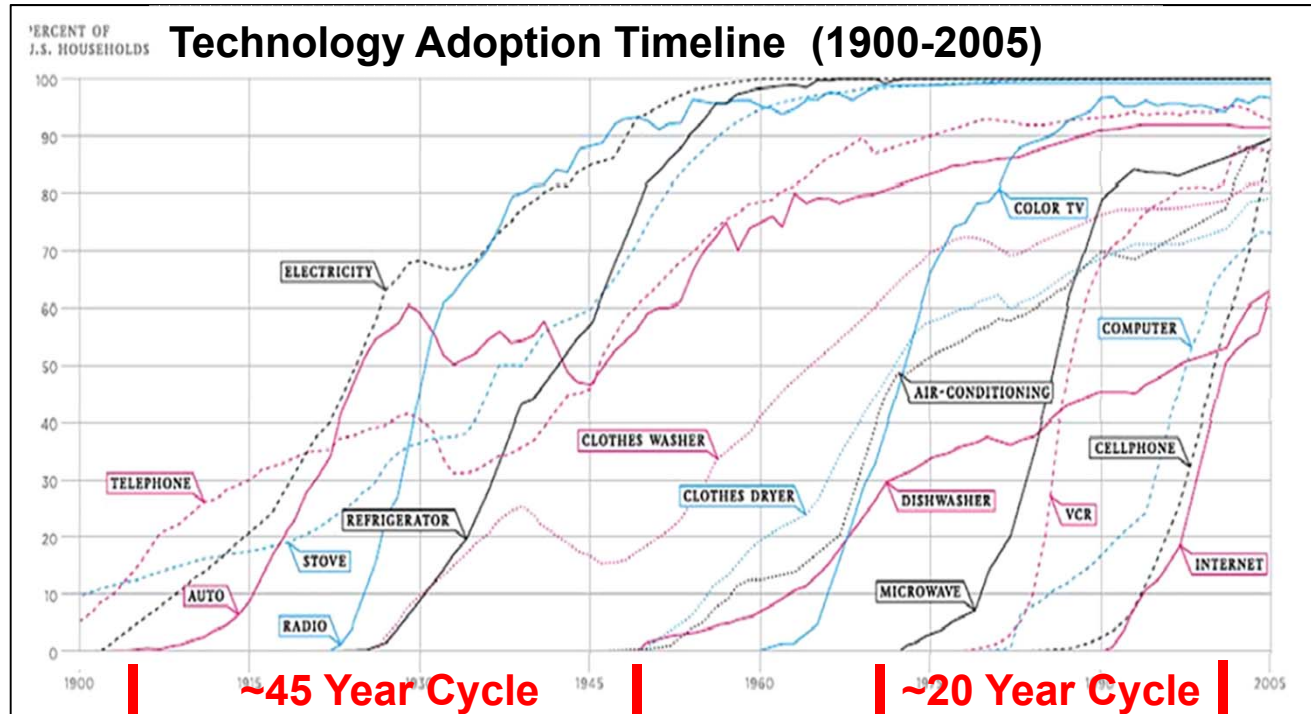
Source: World Bank

The Economist, Feb. 9, 2008

It took 23 years to go from modeling germanium semiconductor properties to a commercial product

The carbon nanotube was discovered in 1991; recognized as an excellent source of field-emitting electrons in 1995, and commercialized in 2000

Technology Adoption Timeline (1900-2005)



The Pace of Technology Development and Market Availability is Exceeding the Pace of Acquisition



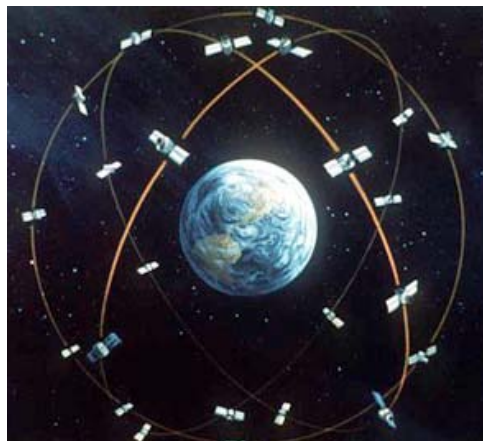
Rise of the Commons



Electronic Warfare



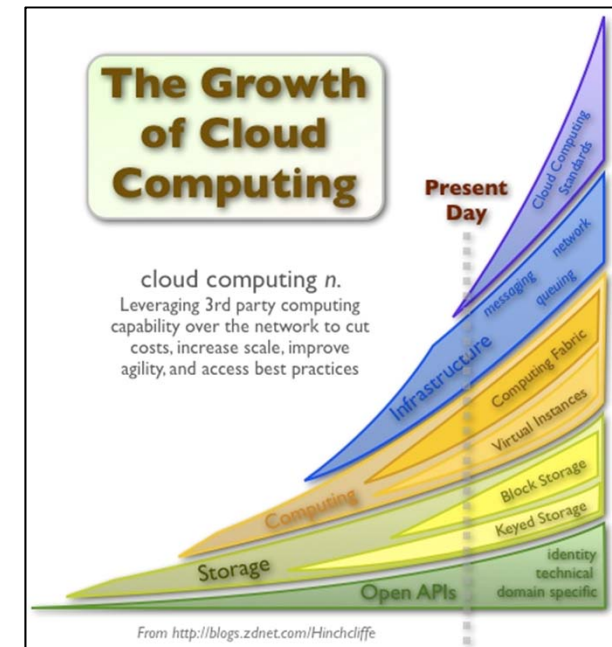
Oceans



Space



Cyber

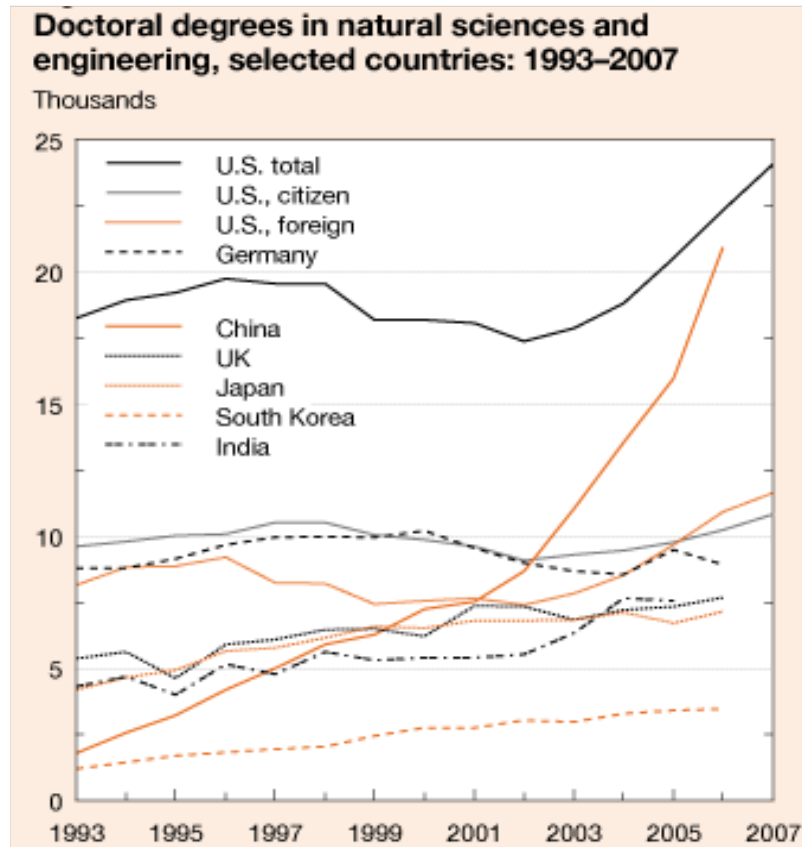


Ubiquitous Data

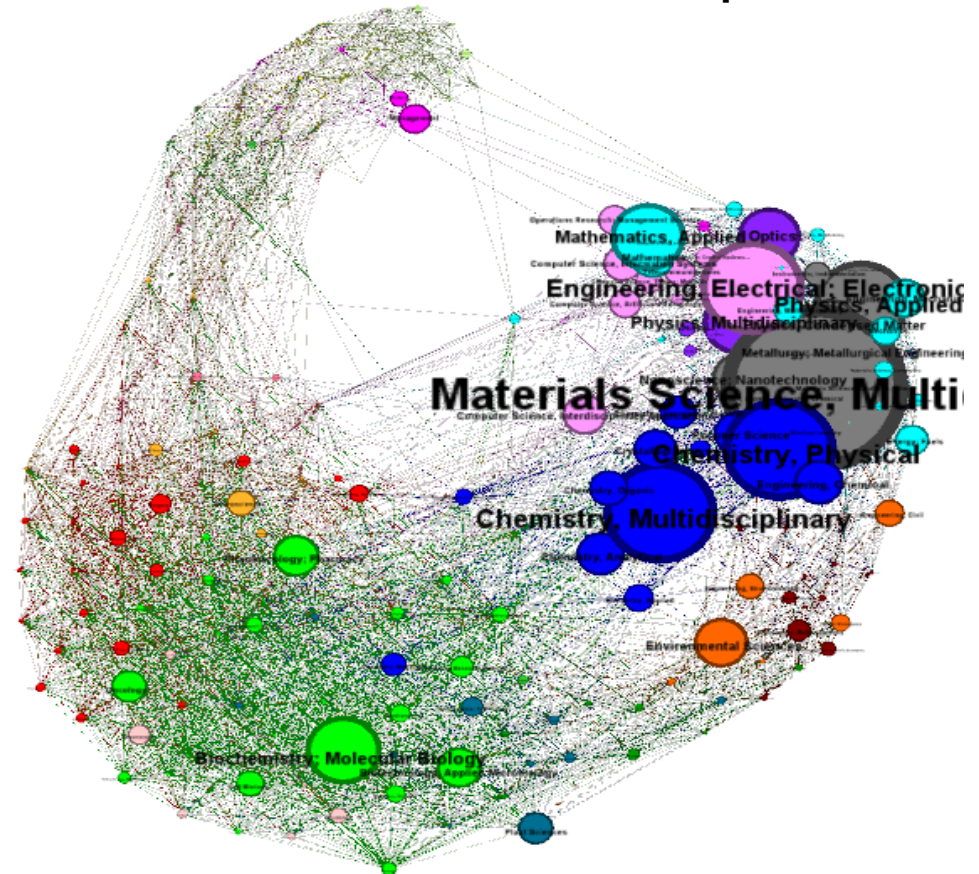
Military Operations Increasingly Depend on Being Able to Operate in Places “No One Owns” – *The Commons*



Expanding Global Knowledge Base



China 2010 Science Map

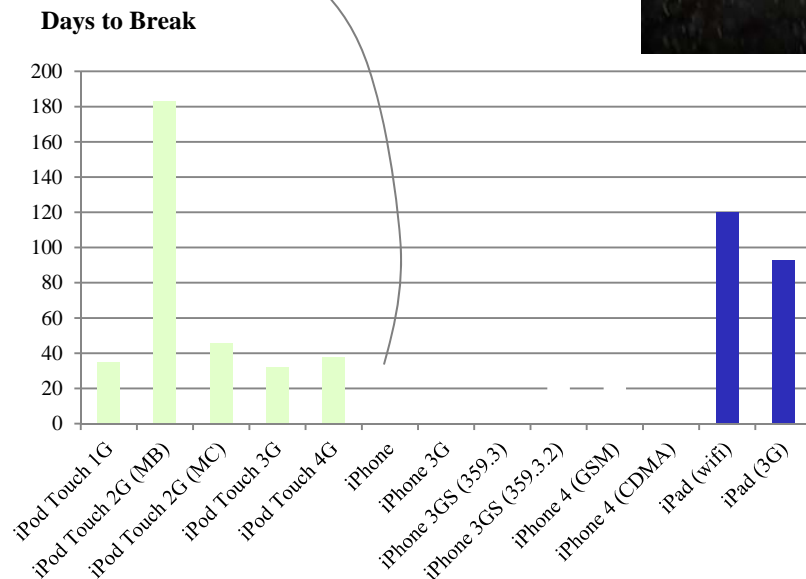


The Research Talent Base is Growing and Shifting at an Accelerating Rate



Information Agility

Apple and AT&T released the iPhone on 29 June in an exclusive agreement. Hotz spent ~500 hours working on his "summer project" and the hack was available in July.



This is the New Asymmetry—Victory Goes to the Agile and Innovative



Mass Collaboration



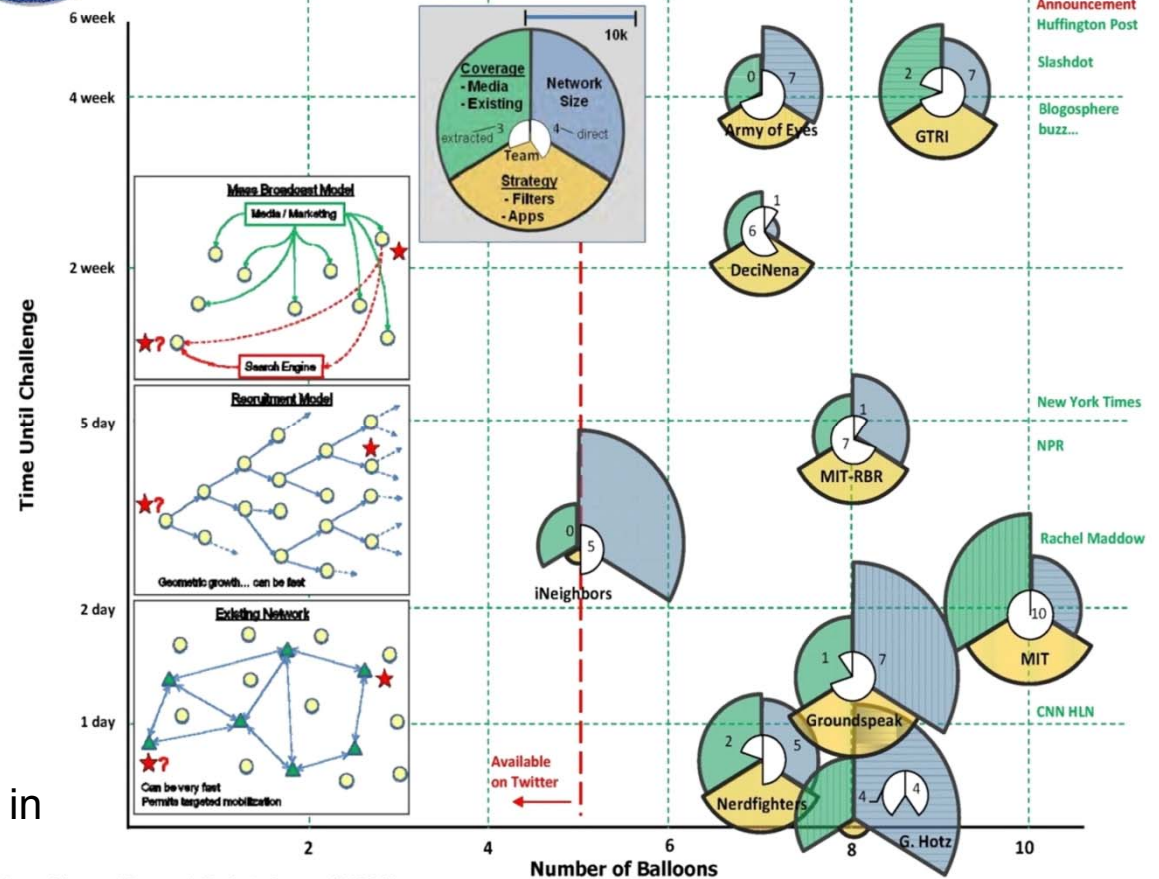
DARPA Network Challenge



- Winter 2009
- DARPA “Red Balloon Challenge”
- Marks 40th Anniversary of ARPANet
- Basic research issues such as mobilization, collaboration, and trust in diverse social networking constructs



Network Challenge Team Performance



Defense Advanced Research Projects Agency (DARPA)
2009 Network Challenge

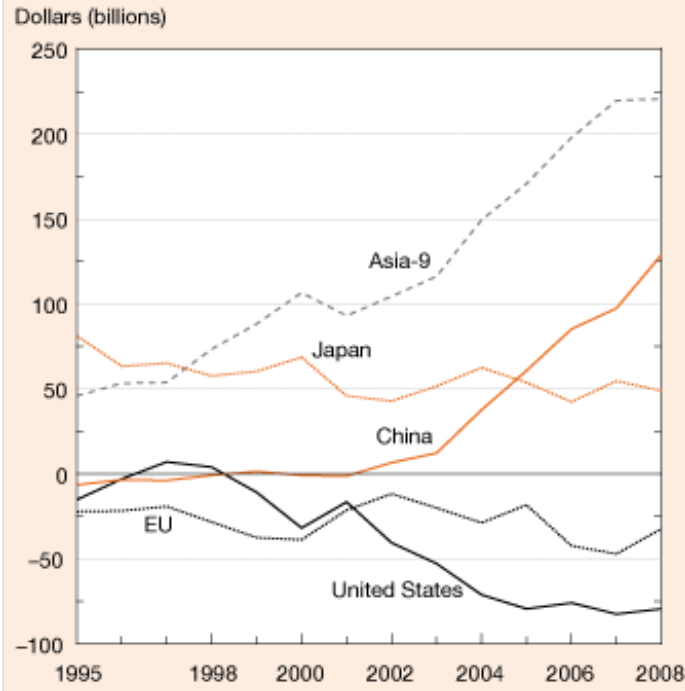
Ad-hoc Groups Can Quickly Solve (or Create) Massively-Complex Problems



Economic and S&T Mega Trends



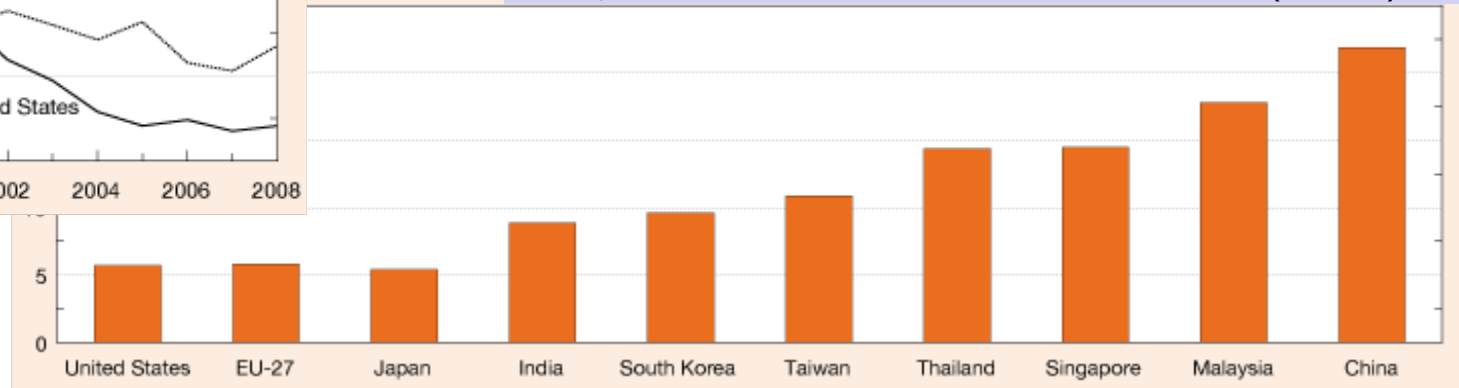
Trade balance in high-technology goods for selected regions/countries: 1995–2008



Global S&T Trends:

- Discipline Convergence
- Lateral Development
- Manufacture Migration
- Shorter Maturation Cycle

Average annual growth of R&D expenditures for United States, EU-27, and selected Asia-8 economies: 1996-2007 (% GDP)



Where will tomorrow's advantage come from?



Technology Commercialization



INNOVATION LEADERS

These 10 companies are spending the most on research and development.

TECHNOLOGY

Crash-Proof Code
Homomorphic Encryption
Cloud Streaming
Gestural Interfaces
Social Indexing
Smart Transformers
Solid-State Batteries
Synthetic Cells
Cancer Genomics
Separating Chromosomes

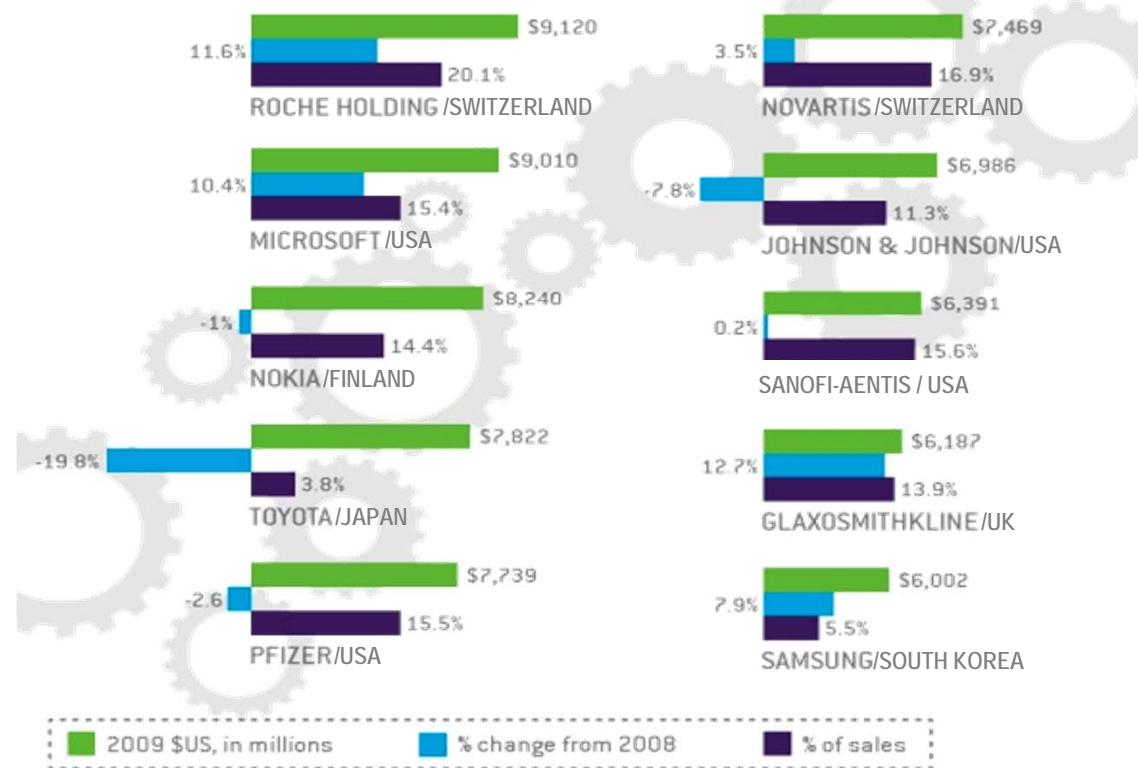
DRIVER

Developers

Cyber Users

Energy

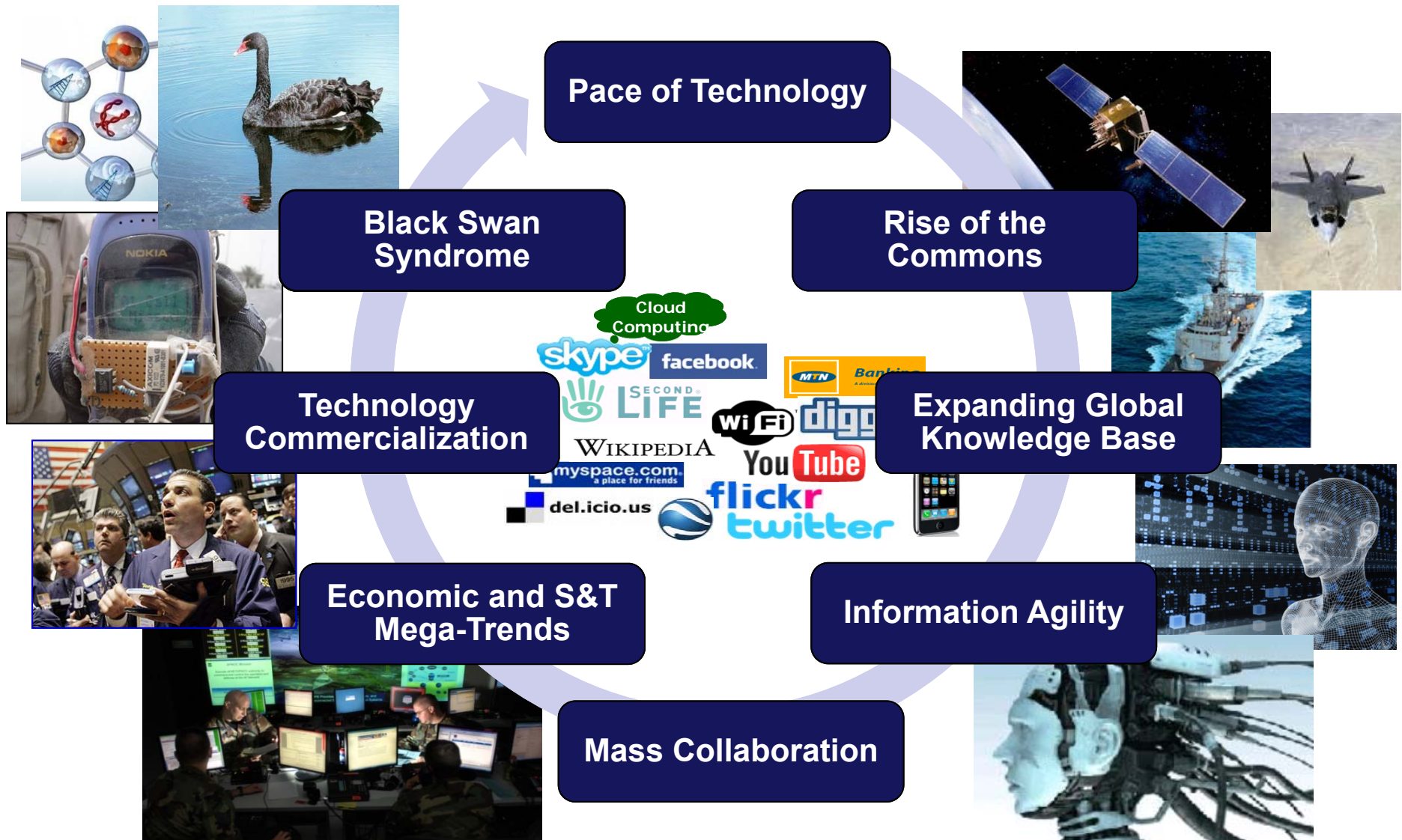
Medical consumers



The global commercial marketplace (not the military) drives and fuels the need for and development of new innovative concepts and capabilities.



A New Reality: *Global Dimensions Affect DoD S&T*





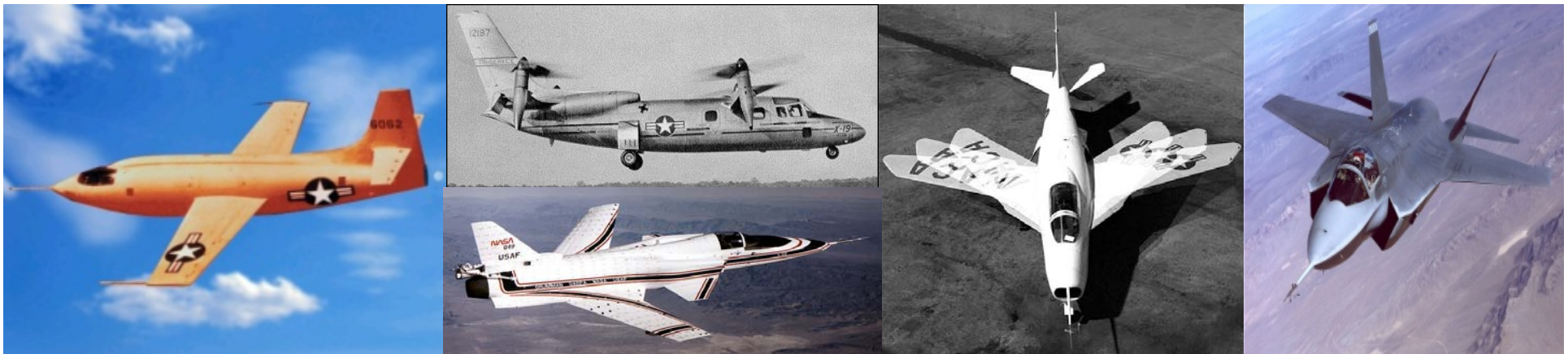
Prototyping

The Department can cost-effectively drive innovation in aviation, space, maritime and ground combat systems through prototyping

Proof of Concept:

“X”- Plane Prototyping

Prototype Development Programs have expanded the state of the possible in military aviation without each necessarily driving a follow-on procurement activity





Capability Prototyping Example: X-Planes



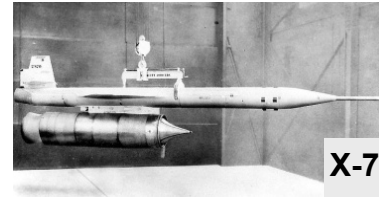
X-1

First flight: 1947
Speed: Mach 1.26



X-2

First flight: 1952
Speed: Mach 3.2



X-7

First Flight: 1951
Speed: Mach 4.31



X-10

First Flight: 1953
Speed: Mach 2



X-15

First Flight: 1959
Speed: Mach 6.7



X-43

First Flight: 2001
Speed: Mach 6.83



X-51

First Flight: 2010
Speed: Mach 5.1

The Department can cost-effectively drive innovation in aviation, space, maritime and ground combat systems through prototyping



DASD, Systems Engineering Mission



Systems Engineering focuses on engineering excellence – the creative application of scientific principles:

- To design, develop, construct and operate complex systems
- To forecast their behavior under specific operating conditions
- To deliver their intended function while addressing economic efficiency, environmental stewardship and safety of life and property

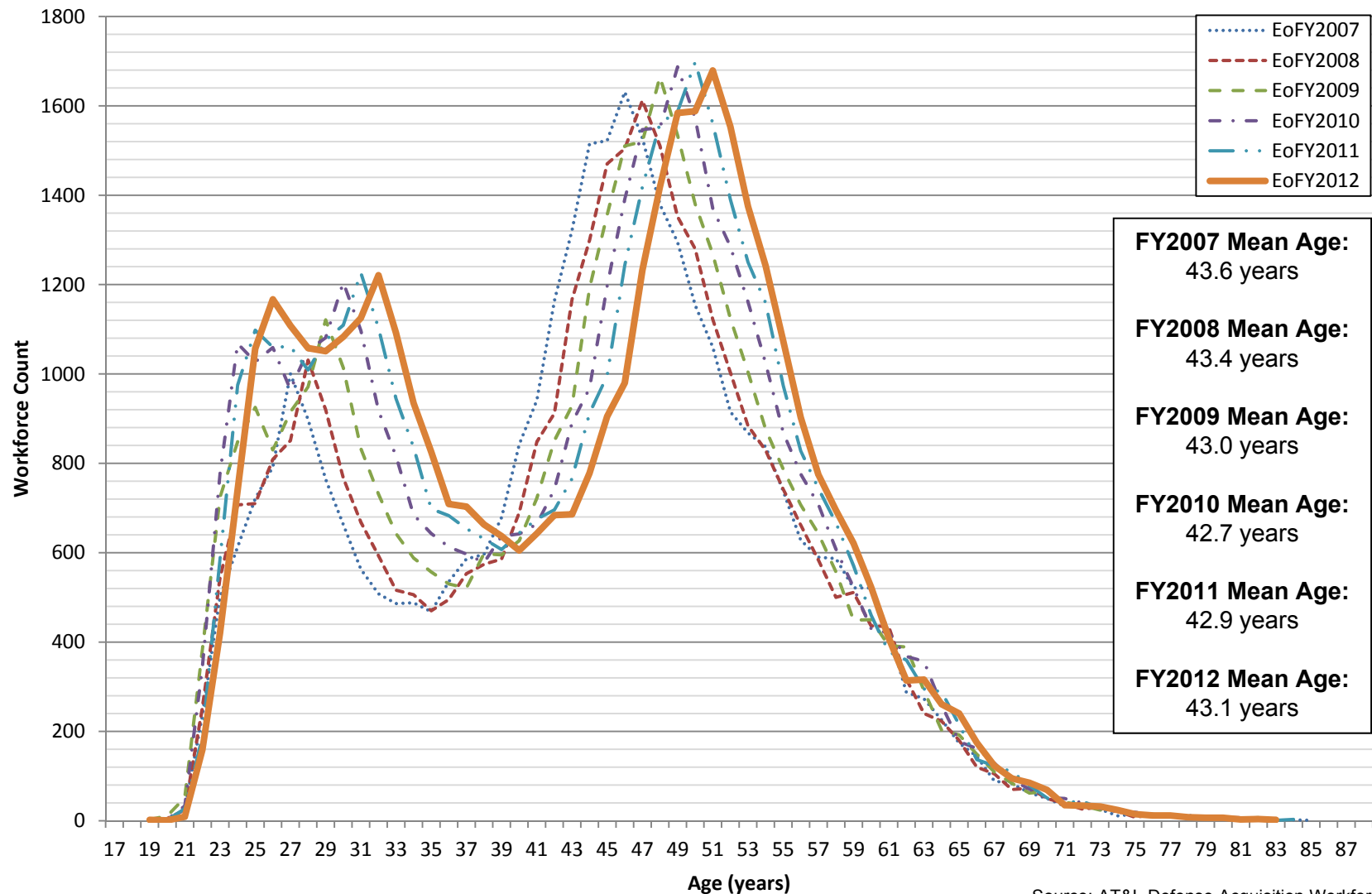
DASD(SE) Mission: Develop and grow the Systems Engineering capability of the Department of Defense – through engineering policy, continuous engagement with component Systems Engineering organizations and through substantive technical engagement throughout the acquisition life cycle with major and selected acquisition programs.

A Robust Systems Engineering Capability Across the Department Requires Attention to Policy, People and Practice

- ***US Department of Defense is the World's Largest Engineering Organization***
- ***Over 99,000 Uniformed and Civilian Engineers***
- ***Over 39,000 in the Engineering (ENG) Acquisition Workforce***



DoD ENG Workforce: Age Demographics



Source: AT&L Defense Acquisition Workforce Data Mart



Summary



- **DoD is focused on maintaining technological superiority in an era of constrained resources.**
- **Future operations capabilities depend on today's research achievements. DoD is working to advance critical differentiating technologies, address technological maturity cost and risk of critical technologies.**
- **DoD's research and engineering focus is evolving to leverage and address the increasingly globalized technology environment.**
- **Prototyping and engineering are critical enablers in a resource constrained environment**



Systems Engineering: Critical to Defense Technologies



Innovation, Speed, Agility

<http://www.acq.osd.mil/se>